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Predictive Model of Metal Corrosion in Trans-Amadi, Obio-Akpor Local Government Area, Port Harcourt

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ABSTRACT

Steel is one of the major construction materials used in the industries. It has a young modulus of 200GNm^{-2}. This research work focuses on the experimental study of predicting and determining the corrosion rate for carbon steel, cast iron and stainless steel in different media namely; underground (soil) and salt water environment sourced from Trans-Amadi Local Government area, Port Harcourt. The laboratory immersion test remains the best method of screening of metals. It remains the quickest and most economical means for providing a preliminary selection of best suited materials for engineering applications as there is no simple way to extrapolate the results obtained from this simple test to the predictions of systems service lifetime. The experimental period of three months, was considered for the determination of the weight loss, rate of corrosion for both calculated and a model for its prediction was developed. The exposure period was varied between 7, 14, 21, 28, 35, 42, 49, 56, 63 and 70 days. From the study the corrosion behaviour of carbon steel, cast iron and stainless steel have been evaluated based on exposure location.

Key words: Predictive, model, metal, corrosion, Trans-Amadi, Obio-Akpor Local Government Area, Port Harcourt

1. INTRODUCTION

The main concern related to the useful life of buried steel structures is corrosion. Corrosion is the degradation of the steel that ends up causing the failure of the infrastructure. It is an essential factor in the design phase of such infrastructures, not only for its implications in structural resistance but also for its importance in economic calculation, as it implies costly maintenance in the phase of exploitation [1-5]. Because of corrosion, metallic buried structures must be regularly inspected, maintained, and occasionally replaced [6]. Furthermore, the failure of these structures presents serious risks to human health and the environment. For instance, when a foundation fails, it is possible that the structure that it supports also fails or leads to the leakage of dangerous substances which can trigger dangerous explosions [7-9].

In order to arrest these problems, much has been done and much more is still being carried out to determine rate of metals in different media and how to

induce corrosion preventive or remedial measures and control systems and hence save costs by preventing equipment failure, damage and promote the safety of personnel phenomena [10-13]. Corrosion in a given environment can determine the life expectancy of a facility depending on the material of construction [14-17]

The aim of this research work is to monitor the corrosion rate of the various metals on Trans-Amadi Industrial Area of Obio-Akpor Local Government Area of Rivers State. The following objectives were considered in this project such as to: Develop a mathematic model to predict metal corrosion, examine metal corrosion in water and soil medium in Trans-Amadi environment and validate the model.

The scope of this work is to predict/determine the rate of corrosion of carbon steel, mild steel and stainless steel in two different mediums, how corrosion affects the various selected metals in the soil and salt water environment and to know the corrosion rate (weight loss) when immersed in these environments.

Significance of the Study

In this study, it is our optimum hope that this research/project work would among other things; address the fundamental issues of corrosion and its effect on underground pipes and other process equipments, supply facts which can assist the engineers in selecting the best materials for construction of an equipment exposed especially to a corrosive environment, assist in the easy achievement of corrosion research work, assist other students who may likely carry out further research on related areas in partial fulfillment of their graduation requirements and supply facts to assist the government to design and implement relevant programmes to protect public facilities against external corrosion.

The significance of this study is to determine and provide a comparative analysis on the rate at which steel corrodes in the different environments and as a result re-awakening the readiness of the material engineering to control this rate of corrosion thereby increasing the service life of steel when used in any of the environments.

2. MATERIALS AND METHOD

Experiment

This research work was carried out by using soil, water medium and metals, in order to predict and actualize their rates of corrosion using the method of metal loss/gain techniques.

When carrying out an experiment on the prediction/determination of the rate of corrosion of carbon steel, mild steel and stainless steel in soil and aqueous environment, we are testing to know the weight loss of the various selected metals when it is exposed to soil and aqueous media that was used in calculating and predicting the corrosion rate of the selected metals.

The test was performed at room temperature (29 ± 0.4^0c) in the Department of Chemical Engineering Laboratory of the Rivers State University; precautions were taken to obtain good result.

The susceptibility of many metal materials to rapid corrosion in sea water condition places several limitations on their use for fabrication of under seawater facilities such as pipelines and fluid storage tanks.

Apparatus Used and Reagents

The following were the apparatus used for this experiment: Vernier caliper, Analytical balance, Beaker and conical flask and Iron brush file. Materials used for the experiment include: Sand paper, Distilled water, Supporting rod, Ropes, Carbon steel, Cast iron, Stainless steel, Detergent, Sandy Soil sample (Solid environment), Salt water (Aqueous environment).

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Figure 1: Map of Rivers State Showing Obio-Akpor Local Government Area

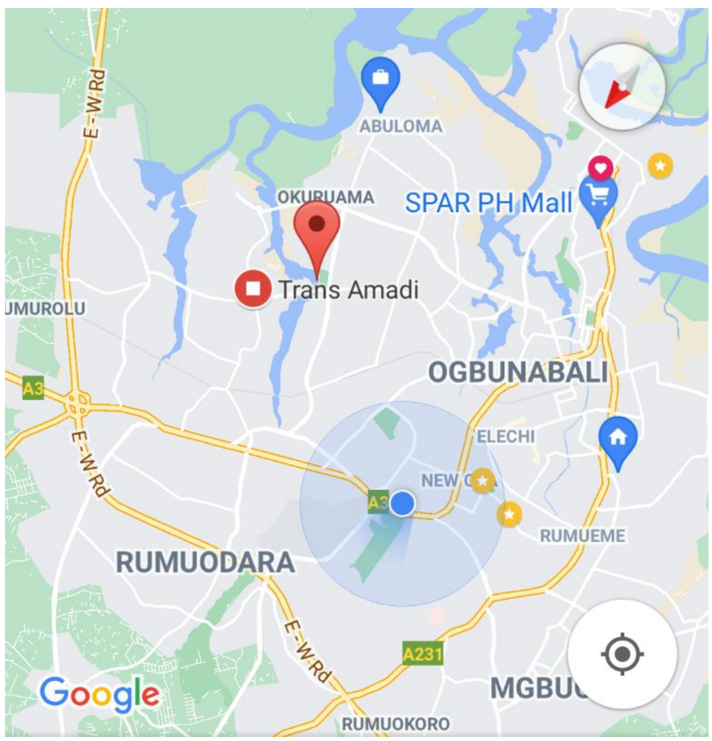

Figure 2: Map of Trans Amadi Industrial Area, Obio-Akpor Local Government Area Sample Source.

The environment samples used for this experiment were obtained from Trans-Amadi Industrial Area, Obio-Akpor Local Government Area of Rivers State, which is demonstrated in Figure 1 and Figure 2.

The samples of various metals for this experiment includes: Carbon steel, cast iron and stainless steel, which were cut into rectangular shape using ruler to know the length and width of the various selected steel metals; vernier caliper was used to measure the thickness of carbon steel, cast iron and stainless steel. Two samples of carbon steel, cast iron and stainless steel were provided. Measurements were taken for the experiment.

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Experimental Procedures/Method

Metal Loss/Gain Detection Method

Figure 3: Monitoring Metal Coupons in Different Corrosive Mediums after Time (t).

A smoothing file and sand paper were used to dress the edges of the selected steel metals to remove rough filling to avoid accelerated corrosion at the edges. A hole was drilled in the middle of the various selected metals and a rope was tied through, for easy immersion and removal. Initial weight of carbon steel, cast iron and stainless steel were measured using the analytical balance and recorded as presented in Figure 3.

A beaker containing soil and containing seawater were provided; each selected metal was suspended or immersed in the corrosion medium through a supporting rod and rope. Each beaker was carefully labeled to distinguish the beakers.

This is followed by immersing the various selected metals (carbon steel, stainless and cast iron) into the beaker containing the corrosive medium. The various selected metals were monitored for a period of 7, 14, 21, 28, 35, 42, 49, 56, 63, 70 days. After the expiration of the exposed time, the various selected metals was removed from the beaker.

Cleaning Procedure

These are several ways of cleaning the specimen after removal from the exposed location. One common cleaning procedure consists of holding the specimen under a stream of tap water and vigorously scrubbing the surfaces of the steel metal with a rubber stopper. The rubber stopper cleaning methods has been found satisfactory for most corrosion test in practical application involving aqueous solution and also for many other test.

Cleaning method may be classified as:

i. Mechanical, such as scraping, brushing, scrubbing with abrasive, sand blasting and rubber stopper.
ii. Chemical such as the use of chemical and solvent.
iii. Electrolytic which involve making the specimen the cathode under an impressed current in a variety of chemical reagent with or without inhibitor added.

The method used here in cleaning the specimen is mechanical method; the specimen was removed from the exposed location and washed with distilled water to remove sand, debris and other impurities. An iron brush was used to scrub the oxide film formed on the various steel metals and while using the brush, care was taken to ensure no further loss of metal apart from the film formed on the steel metals (carbon steel, cast iron and stainless steel).

After the removal of the specimen from the exposed locations and cleaning process is carried out, the specimens are dried and weighed on an analytical balance. The weight loss of each exposed time is recorded, the recorded weight loss was used in calculating the corrosion rate

After which, a mathematical model is developed, examined and tested to predict the rate of corrosion of stainless steel, cast iron, and carbon steel.

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3. RESULTS

The weight loss method, for each week data obtained using the analytical weighing balance and the difference in weight for each of the week was then calculated; that is the difference between the weight of each metal specimen or coupon before and after each week of the immersion of the sample in the different environments.

Model Development

The development for a corrosion process from first principle of conservation of matter and energy depicts faults due to some factors (factors affecting corrosion) which require careful considerations.

The best method of developing the model is by plotting experimental data and solving to obtain the mathematical model equation.

Time (t) in weeks

Final weight of metal coupon W_f

Initial weight of metal coupon W_i

Table 1: Determination of Weight Loss for Metals Immersed In Salt Water Medium

	Stainless Steel Immersed in Salt Water			**Cast Iron Immersed in Salt Water**			**Carbon Steel Immersed in Salt Water**		
Time (Weeks)	Initial Weight	Final Weight	Weight Loss	Initial Weight	Final Weight	Weight Loss	Initial Weight	Final Weight	Weight Loss
1	147.814	147.792	0.02	147.474	147.414	0.06	183.021	182.821	0.2
2		147.694	0.12		147.344	0.13		182.621	0.4
3		147.514	0.3		147.274	0.2		182.421	0.6
4		147.394	0.42		147.234	0.24		182.331	0.69
5		147.314	0.5		147.174	0.3		182.221	0.8

Table 2: Determination of Weight Loss for Metals Immersed in Soil

Carbon Steel Immersed in Soil			**Stainless Steel Immersed in Soil**			**Cast Iron Immersed in Soil**		
Initial Weight	Final Weight	Weight Loss	Initial Weight	Final Weight	Weight Loss	Initial Weight	Final Weight	Weight Loss
195.35	195.15	0.2	149.844	149.824	0.02	149.84	149.82	0.02
	194.95	0.4		149.774	0.07		149.77	0.07
	194.63	0.6		149.694	0.15		149.72	0.12
	194.53	0.67		149.644	0.2		149.65	0.19
	194.61	0.74		149.604	0.24		149.63	0.21

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Cast Iron Immersed in Sandy Soil Medium

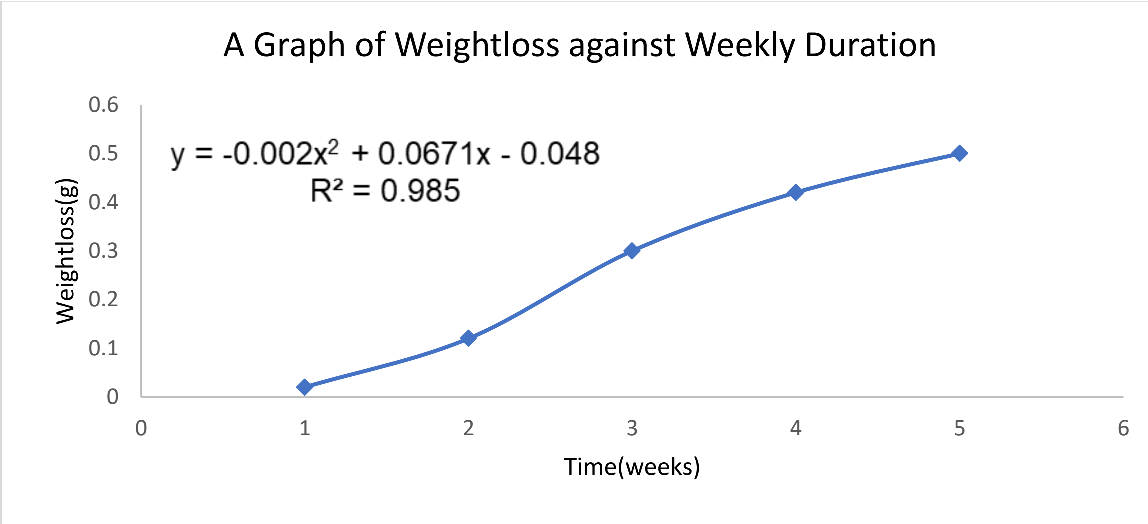

Figure 4. A Graph of Weight loss against Time for Cast Iron Immersed in Sandy Soil Medium.

Figure 4. show cases the plot of weight loss of cast iron immersed in sandy soil environment with the influence of time being studied. Increase in weight loss was observed with increase in time. The variation in the weight loss can be attributed to variation in time as well as soil characteristics. The equation of the line is given as; $y = -0.002x^2 + 0.0671x - 0.048$. With the square root of best fit $R^2 = 0.985$. The reliability of figure 4 reveals 98.5% values indicating the acceptability of the obtained result.

Stainless Steel Immersed in Sandy Soil Medium

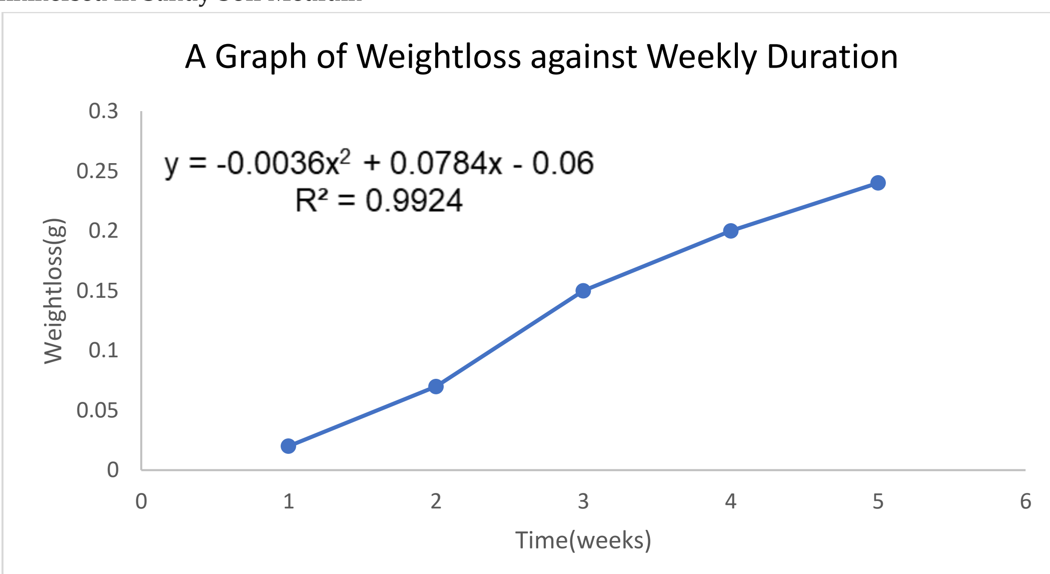

Figure 5: A Graph of Weight Loss against Time for Stainless Steel Immersed in Sandy Soil Medium

Figure 5 show cases the plot of weight loss of stainless steel immersed in sandy soil environment with the influence of time being studied. Increase in weight loss was observed with increase in time. The variation in the weight loss can be attributed to variation in time as well as soil characteristics. The equation of the line is given as; $y = -0.0036x^2 + 0.0784x - 0.06$. With the square root of best fit $R^2 = 0.9924$. The reliability of Figure 5 reveals 99.24% values indicating the acceptability of the obtained result.

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Carbon Steel Immersed in Sandy Soil Medium

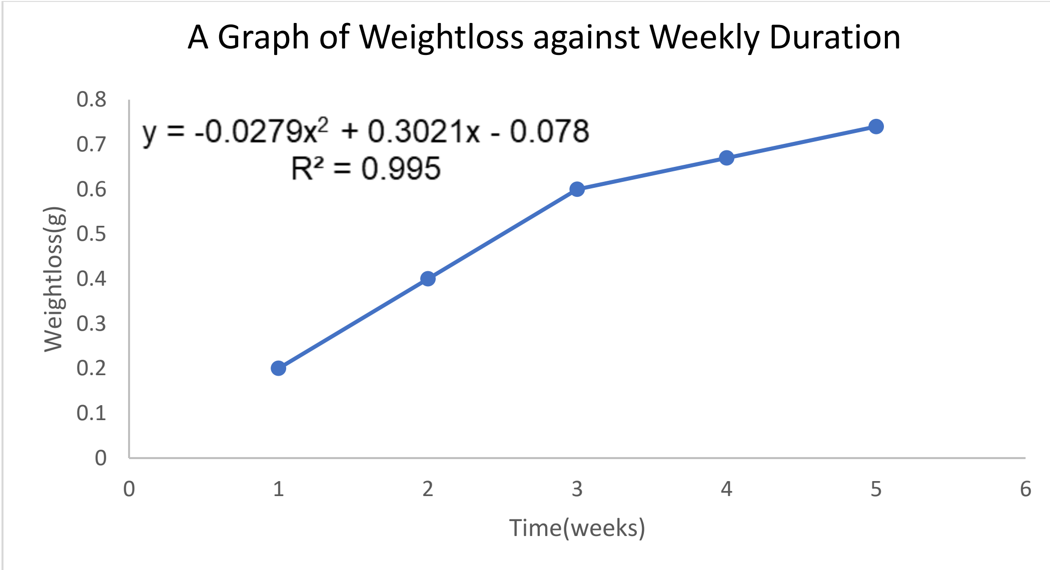

Figure 6: A Graph of Weight Loss against Time for Carbon Steel Immersed in Sandy

Soil Medium

Figure 6 showcases the plot of weight loss of carbon steel immersed in sandy soil environment with the influence of time being studied. Increase in weight loss was observed with increase in time. The variation in the weight loss can be attributed to variation in time as well as soil characteristics. The equation of the line is given as; $y = -0.0279x^2 + 0.3021x - 0.078$. With the square root of best fit $R^2 = 0.995$. The reliability of figure 4.1 reveals 99.5% values indicating the acceptability of the obtained result.

Cast Iron Immersed in Salt Water Medium

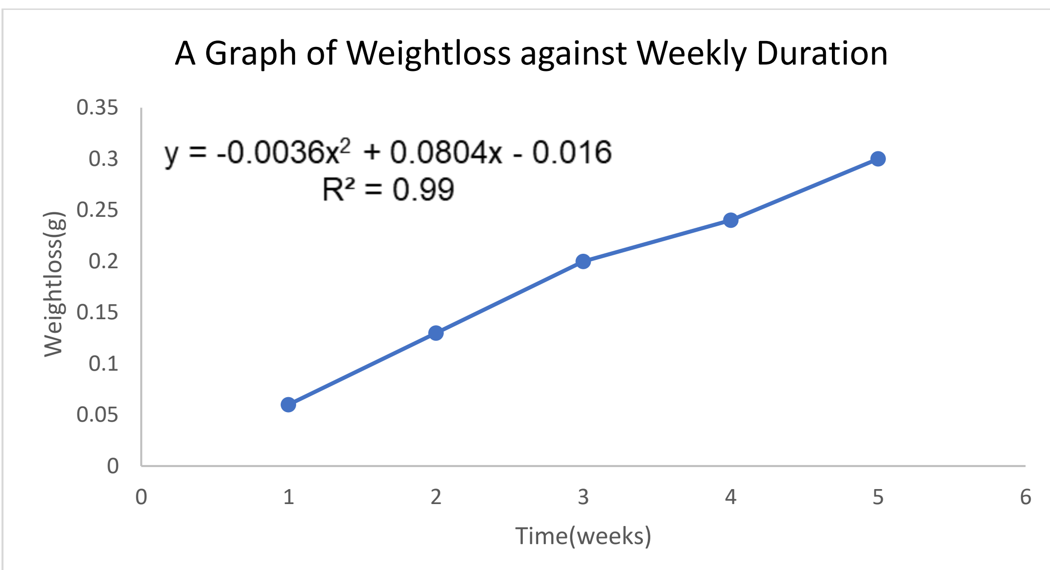

Figure 7: A Graph of Weight Loss against Time for Cast Iron Immersed in Salt Water Medium

Figure 7 show cases the plot of weight loss of cast iron immersed in salt water environment with the influence of time being studied. Increase in weight loss was observed with increase in time. The variation in the weight loss can be attributed to variation in time as well as salt water characteristics. The equation of the line is given as; $y = -0.0036x^2 + 0.0804x - 0.016$. With the square root of best fit $R^2 = 0.99$. The reliability of Figure 7 reveals 99.0% values indicating the acceptability of the obtained result.

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Carbon Steel Immersed in Salt Water Medium

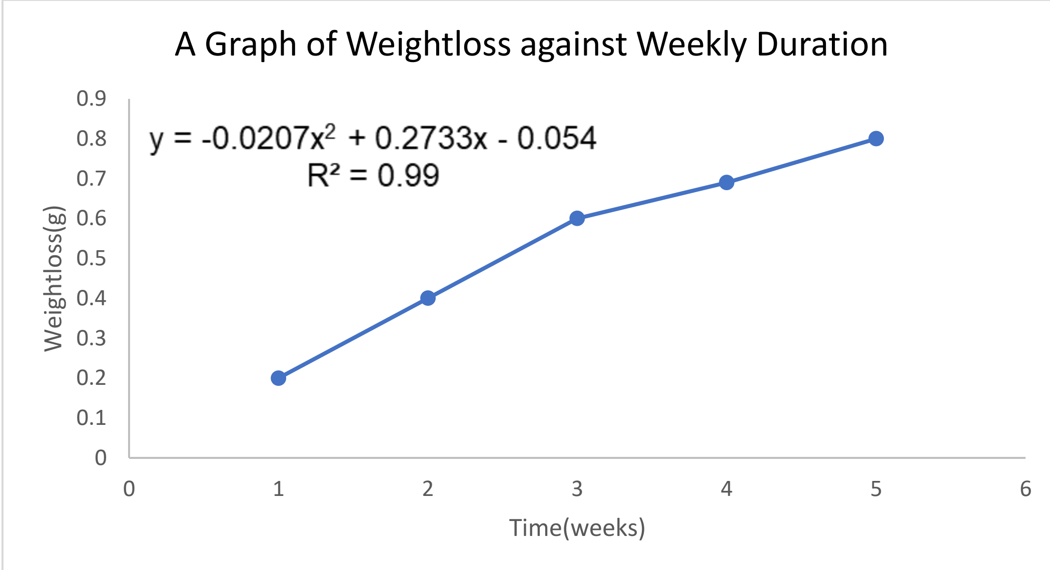

Figure 8: A Graph of Weight Loss against Time for Carbon Steel Immersed in Salt Water

Medium

Figure 8 show cases the plot of weight loss of carbon steel immersed in salt water environment with the influence of time being studied. Increase in weight loss was observed with increase in time. The variation in the weight loss can be attributed to variation in time as well as salt water characteristics. The equation of the line is given as; $y = -0.0207x^2 + 0.2733x - 0.054$. With the square root of best fit $R^2 = 0.99$. The reliability of Figure 8 reveals 99.0% values indicating the acceptability of the obtained result.

Stainless Steel Immersed in Salt Water Medium

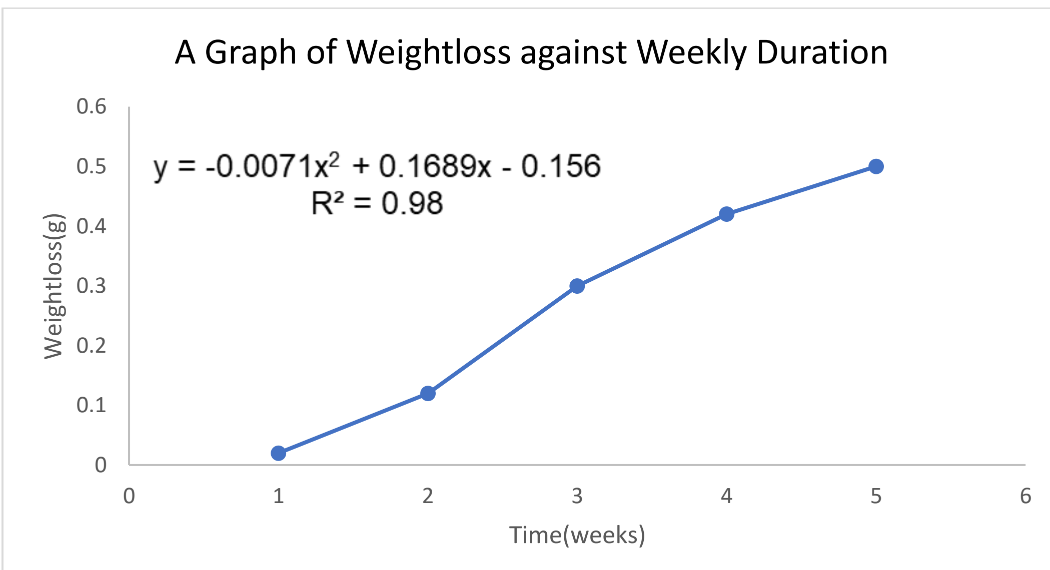

Figure 9: A Graph of Weight Loss against Time for Stainless Steel Immersed in Salt Water Medium

Figure 9 show cases the plot of weight loss of stainless steel immersed in salt water environment with the influence of time being studied. Increase in weight loss was observed with increase in time. The variation in the weight loss can be attributed to variation in time as well as salt water characteristics. The equation of the line is given as; $y = -0.0071x^2 + 0.1689x - 0.156$. With the square root of best fit $R^2 = 0.98$. The reliability of figure 9 reveals 98.0% values indicating the acceptability of the obtained result.

From graphical analysis, the mathematical model showing how the final weight of the metal coupons is changing over a period of time is given below;

Model for Weight loss of Cast Iron Immersed in Saltwater Medium

$y = -0.003x^2 + 0.080x - 0.016$

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Model for Weight loss of Cast Iron Immersed in Sandy Soil Medium

$y = -0.002x^2 + 0.0671x - 0.048$

Model for Weight loss of Carbon Steel Immersed in Saltwater Medium

$y = -0.020x^2 + 0.273x - 0.054$

Model for Weight loss of Carbon Steel Immersed in Sandy Soil Medium

$y = -0.027x^2 + 0.302x - 0.078$

Model for Weight loss of Stainless Steel Immersed in Saltwater Medium

$y = -0.007x^2 + 0.168x - 0.156$

Model for Weight loss of Stainless Steel Immersed in Sandy Soil Medium

$y = -0.003x^2 + 0.078x - 0.06$

Model Validation

Cast Iron Immersed in Salt Water Environment

$y = -0.0036x^2 + 0.0804x - 0.016$

when x = 1 week

$y = -0.0036(1^2) + 0.0804(1) - 0.016$

$y = 0.0608g$

when x = 2 weeks

$y = -0.0036(2^2) + 0.0804(2) - 0.016$

$y = 0.1304g$

when x = 3 weeks

$y = -0.0036(3^2) + 0.0804(3) - 0.016$

$y = 0.1928g$

when x = 4 weeks

$y = -0.0036(4^2) + 0.0804(4) - 0.016$

$y = 0.248g$

when x = 5 weeks

$y = -0.0036(5^2) + 0.0804(5) - 0.016$

$y = 0.3g$

Cast Iron Immersed in Sandy Soil Environment

$y = -0.0029x^2 + 0.0671x - 0.048$

when x = 1 week

$y = -0.0029(1^2) + 0.0671(1) - 0.048$

$y = 0.02g$

when x = 2 weeks

$y = -0.0029(2^2) + 0.0671(2) - 0.048$

$y = 0.07g$

when x = 3 weeks

$y = -0.0029(3^2) + 0.0671(3) - 0.048$

$y = 0.12g$

when x = 4 weeks

$y = -0.0029(4^2) + 0.0671(4) - 0.048$

$y = 0.18g$

when x = 5 weeks

$y = -0.0029(5^2) + 0.0671(5) - 0.048$

$y = 0.21g$

Stainless Steel Immersed in Salt Water Environment

$y = - 0.0071x^2 + 0.1689x - 0.156$

when x= 1 week

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$y = -0.0071(1)^2 + 0.1689(1) - 0.156$

$y = 0.01g$

when x= 2 weeks

$y = -0.0071(2)^2 + 0.1689(2) - 0.156$

$y = 0.1534g$

when x= 3 weeks

$y = -0.0071(3)^2 + 0.1689(3) - 0.156$

$y = 0.2868g$

when x= 4 weeks

$y = -0.0071(4)^2 + 0.1689(4) - 0.156$

$y = 0.406g$

when x = 5 weeks

$y = -0.0071(5)^2 + 0.1689(5) - 0.156$

$y = 0.51g$

Stainless Steel Immersed in Sandy Soil Environment

$y = -0.0036x^2 + 0.0784x - 0.06$

when x = 1 week

$y = -0.0036(1)^2 + 0.0784(1) - 0.06$

$y = 0.0148g$

when x = 2 weeks

$y = -0.0036(2)^2 + 0.0784(2) - 0.06$

$y = 0.0824g$

when x = 3 weeks

$y = -0.0036(3)^2 + 0.0784(3) - 0.06$

$y = 0.01428g$

when x = 4 weeks

$y = -0.0036(4)^2 + 0.0784(4) - 0.06$

$y = 0.196g$

when x = 5 weeks

$y = -0.0036(5)^2 + 0.0784(5) - 0.06$

$y = 0.24g$

Carbon Steel Immersed in Salt Water Environment

$y = -0.0201x^2 + 0.2733x - 0.054$

when x = 1 week

$y = -0.0201(1)^2 + 0.2733(1) - 0.054$

$y = 0.1992g$

when x = 2 weeks

$y = -0.0201(2)^2 + 0.2733(2) - 0.054$

$y = 0.4122g$

when x = 3 weeks

$y = -0.0201(3)^2 + 0.2733(3) - 0.054$

$y = 0.585g$

when x = 4 weeks

$y = -0.0201(4)^2 + 0.2733(4) - 0.054$

$y = 0.7176g$

when x = 5 weeks

$y = -0.0201(5)^2 + 0.2733(5) - 0.054$

$y = 0.81g$

ISSN 2278–5469 EISSN 2278–5450 I OPEN ACCESS

Carbon Steel Immersed in Sandy Soil Environment

$y = -0.0279x^2 + 0.3021x - 0.078$

when x = 1 week

$y = -0.0279(1)^2 + 0.3021(1) - 0.078$

y = 0.196g

when x = 2 weeks

$y = -0.0279(2)^2 + 0.3021(2) - 0.078$

y = 0.4146g

when x = 3 weeks

$y = -0.0279(3)^2 + 0.3021(3) - 0.078$

y = 0.5772g

when x = 4 weeks

$y = -0.0279(4)^2 + 0.3021(4) - 0.078$

y = 0.684g

when x = 5 weeks

$y = -0.0279(5)^2 + 0.3021(5) - 0.078$

y = 0.735g

Determination of Corrosion Rate

The most common method for estimating corrosion rate from mass loss is to weight the corroding specimen before and after exposure time making sure that appropriate conversion constants are used to get the rate in the required units. The method in mm/yr can be represented as;

$$C_R = \frac{K \times wl}{A \times T \times D}$$

C_R = Corrosion rate

Corrosion constant, k = 534.

wl = Weight loss (mg)

D = Density of specimen (g/cm^3)

A = Area of specimen (sq.in)

T = Exposure time (weeks)

Density of Carbon Steel = 7.86g/cm^3

Density of cast iron = 7.21g/cm^3

Density of Stainless Steel = 7.86g/cm^3

Cast Iron Immersed in Salt Water Medium

$y = -0.0036x^2 + 0.0804x - 0.016$

Density, D = 7.21g/cm^3

Weight loss, WL = 0.3g

Length = 2.16m

Time = 5 weeks

Inner diameter = 0.23m

Outer Diameter = 0.25m

Area = $2\pi rh$ = 2x3.142 x 0.125 x 2.16

Area = 1.70m^2

$$C_R = \frac{543WL}{DAT}$$

$$C_R = \frac{543 \times 0.21}{7.21 \times 1.70 \times 5} = \frac{162.9}{61285}$$

C_R = 0.002g/week

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C_R = 0.000002kg/week

Cast Iron Immersed in Soil Medium

y = -0.0029x² + 0.0671x - 0.048

Density, D = 7.21g/cm³

Weight loss, WL = 0.21g

Length = 2.16m

Time= 5 weeks

Inner diameter = 0.23m

Outer Diameter = 0.25m

Area = 2πrh = 2x3.142 x 0.125 x 2.16

Area = 1.70m²

$C_R = \frac{543WL}{DAT}$

$C_R = \frac{0.3 \times 543}{7.21 \times 1.70 \times 5} = \frac{162.9}{61285}$

C_R = 0.003g/week

C_R = 0.000003kg/week.

Stainless Steel Immersed in Salt Water Medium

y = - 0.0071x² + 0.1689x - 0.156

Weight loss, WL = 0.5g

Density, D = 7.86g/cm³

Length = 2.06m

Inner diameter = 0.29m

Outer diameter = 0.31m

Area = 2πrh = 2x3.142 x 0.155 x 2.06

Area = 2.01m²

Time = 5 weeks

$C_R = \frac{543WL}{DAT}$

$C_R = \frac{543 \times 0.5}{7.86 \times 2.01 \times 5} = \frac{271.5}{78.993}$

C_R = 3.44g/week

C_R =0.00344kg/week

Stainless Steel Immersed in Soil Medium

y = -0.0036x² + 0.0784x – 0.06

Weight loss, WL = 0.24g

Density, D = 7.86g/cm³

Length = 2.06m

Inner diameter = 0.29m

Outer diameter = 0.31m

Area = 2πrh = 2 x 3.142 x 0.155 x 2.06

Area = 2.01m²

Time = 5 weeks

$C_R = \frac{543WL}{DAT}$

ISSN 2278–5469 EISSN 2278–5450 I OPEN ACCESS

$C_R = \frac{543 \text{ X } 0.24}{7.86 \text{ X } 2.01 \text{ X } 5} = \frac{130.32}{78.993}$

C_R = 1.65g/week

C_R =0.00165kg/week

Carbon Steel Immersed in Salt Water Medium

$y = -0.0201x^2 + 0.2733x - 0.054$

Weight loss, WL = 0.8g

Density, D = 7.86g/cm^3

Length = 2.03m

Inner diameter = 0.29m

Outer diameter = 0.31m

Area = 2πrh = 2 x 3.142 x 0.155 x 2.03

Area = 1.98m^2

Time = 5 weeks

$C_R = \frac{543WL}{DAT}$

$C_R = \frac{543 \text{ X } 0.8}{7.86 \text{ X } 1.98 \text{ X } 5} = \frac{434.4}{77.814}$

C_R = 5.583g/week

C_R =0.005583kg/week

Carbon Steel Immersed in Soil Medium

$y = -0.0279x^2 + 0.3021x - 0.078$

Weight loss, WL = 0.74g

Density, D = 7.86g/cm^3

Length = 2.03m

Inner diameter = 0.29m

Outer diameter = 0.31m

Area = 2πrh = 2 x 3.142 x 0.155 x 2.03

Area = 1.98m^2

Time= 5 weeks

$C_R = \frac{543WL}{DAT}$

$C_R = \frac{543 \text{ X } 0.74}{7.86 \text{ X } 1.98 \text{ X } 5} = \frac{401.82}{77.814}$

C_R= 5.164g/week

C_R=0.005164kg/week

4. DISCUSSION

In this investigative work, it is comprehended that corrosion reaction unavoidably occurs as a reaction between the metal and the environment. Most often, during the assessment of corrosion in our industries etc. they tend not to appear in a set of patterns. This, being as a result of its complex nature.

This work further confirms that no indestructible materials of any form exist in nature especially metals. And, the extent or rate of deterioration of this material due to corrosion depends mainly on the reactivity characteristics of the metal.

Primarily, all materials including ceramics, woods, plastics etc deteriorates especially at the surface when exposed to any corrosion agent, with the process much faster under atmospheric condition. This atmosphere is usually the oxygen etc which reacts

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with the metals as to produce metallic oxides called rust. But, in every usual case, H_2O vapour has to be present before this oxidation can take place.

Naturally, some of these materials which corrodes tend to have a very short life sperm. Mostly, these characteristics depend on the mechanical, chemical, and design structure of the material. Corrosion in most cases, involves the gain or loss of electrons. This is basically because corrosion is an electrochemical process. For example, a sodium atom gives out one of its electrons to form positively charged sodium (Na^+). While for chlorine, its atom accept electrons to form a negatively charged chlorine ion (Cl^-)

For gain or loss of electrons, any reaction which generates electrons is termed as an oxidation reaction while that which consumes electrons is called reduction reaction.

These metals begin to experience a slight weight loss as soon as corrosion begins and as this happens; this spot where the corrosion occurs immediately changes in colour and causes a film growth.

In the expatiation and understanding of this corrosion rate, the data in the tables are therefore respectively recalled.

From the data obtained from this investigative work carried out, it has been understood that the physical and chemical properties of every pipelines depreciates with respect to time. This corrosion mechanism also becomes more prominent especially when the given material is exposed to the atmosphere. This depreciation (weight loss) was discovered to be instigated by the corrosive agents such as the wind, water, moisture, etc. as a promoter of corrosion, the corrosive agents were also discovered in the experiment to be most common in the external structures of the materials (samples).

Vis-à-vis these data analysis, a calculation and a plot of the weight loss against the time (duration) taken were validated. Also, plots of weight loss against time (duration) taken in each sample under the same medium were differently made and accordingly indicated. These figures 4.1-4.6 were clearly deduced in graphical analysis.

5. CONCLUSION

Corrosion being mostly an environmental and time dependent process, a period of five to six weeks was used in the research. The research which gave room to the prediction of the corrosion rate of mostly the underground pipes (such as stainless steel, carbon steel and cast iron) used for the gas and oil transmission lines has been successfully carried out.

Also, in quest for this study, most of the characteristics of corrosion have been understood especially as it relates to the studied metal coupons, its effects and preventive measures since it can be hazardous to the pipelines in particular and the entire industry if neglected.

The weight loss technique was also, specifically used in all three samples throughout the research. From this, it was therefore, concluded that these individual materials have different properties in different environments.

Similarly, by considering the data and results obtained, further conclusions were unveiled. Therefore, like every other material (especially metals) the corrosion rate of carbon steel, stainless steel and cast iron were discovered to increase with respect to time at different rates in a given corrosive medium. Thus, cast iron which has the highest percentage of carbon content amongst carbon steel and stainless steel possessed the least corrosion rate. In the same sequence of carbon content followed was hence stainless steel. Finally, after stainless steel was carbon steel which has the highest corrosion rate and least carbon content.

pH, temperature and conductivity influence the corrosion rate of steel in oil and gas soil environment due to the nature of contaminants associated with it. The existing corrosion rate model was used to input the mathematical computation of the corrosion value as presented in this research work.

It is observed that the soil and salt water characteristics influence the corrosion rate of metals, therefore, there is need to investigate properly on the soil characteristics and composition before laying pipeline through such soil environment.

Conflict of interest

The authors declare that they have no conflict of interest.

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Data and materials availability

All data associated with this study are present in the paper.

REFERENCES AND NOTES

1. Amadi, S. A., Ukpaka C. P., Jacob B. Neeka., (2004). Mechanisms of the microbial corrosion of aluminum alloys.
2. Amadi, S. A., Ukpaka, C. P., (2016). Evaluation of the metal corrosion in soil environment of Niger Delta Area of Nigeria.
3. Beech, I. B., (2004). Corrosion of technical materials in the presence of biofilms Current understanding and state of the art methods of study, 53: 177-183.
4. Beech, I. B., Gaylarde, C.C., (1990). Adhesion of Desulfovibrio desulfuricans and pseudomonas fluorescens to mild steel surfaces. *Journal of Applied Bacteriology*. 67: 201-207.
5. Charng, T., Lansing, F., (1982). Review of Corrosion Causes and Corrosion Control in a Technical Facility, TDA progress Report, DNS Engineering Section, 5, 42-69.
6. Frange, F. A., (1987). Corrosion in high steel. *Journal of Electrochemical Society* 41, 133-117.
7. Jelenka, B. S., (2010). Reliability and Safety Analysis of the Process Plant, Petroleum & Coal 52(2), 62 – 68. *Journal of Engineering and Technology Research* 4(3), 34-56.
8. McFarland, M. L., Provin, T. L., Boellstorff, D. E., (2008). Drinking Water Problems: Corrosion, A & M AgriLife Extension, 1-5.
9. Robinson, W. (1964). External Corrosion of Cast-Iron Pipe. *Journal American Water Works Association*, 60(12): 1129-1143.
10. Sun, Y, Hong. T, and Bosch C, (2003) Corrosion in the process industry, 59: 733-734.
11. Ukpaka C. P (2016). Metal Diffusion in Stagnant Water Environment in Niger Delta Area of Nigeria. International *Journal of Scientific Research and Engineering* 2(2), 71 – 78.
12. Ukpaka C. P. (2012) Investigation into the kinetics of biodegradation of crude oil in different soils. *Journal of Engineering and Technology Research*, 4(2), 37-55
13. Ukpaka C. P. and Uku P. E (2018). Application of mathematical tools and techniques in monitoring, predicting stainless steel corrosion in river water media environment. *Chemistry International* 4(1), 77-84.
14. Ukpaka C. P., (2005). Investigation of Microbial Influenced Corrosion in Crude Oil Storage Tanks. *Journal of Modeling, Simulation and Control* (AMSE), 66(4) 1-22.
15. Ukpaka C. P., (2016). Metal Diffusion in Stagnant Water Environment in Niger Delta Area of Nigeria. *International Journal of Scientific Research and Engineering* 2(2), 71 – 78
16. Ukpaka C. P., (2016). The Concept of Examination of Biochemical and Chemical Oxygen Demand in Stagnant Water System. *Chemistry Research Journal* 1(1), 35-43.
17. Ukpaka. C. P., Amadi. S.A., I. G. Ahuchogu and Odharo J. (2011) Modeling the rate of bio-corrosion and the effects of redox-reactions of metals in water environment.

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